BIS ENERGY AND ENGINEERING

Volume 2 2025 | DOI: 10.31603/biseeng.372
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Bearing remanufacturing practices: a case study in PT. SKF Indonesia

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Abstract

The primary consequences of greenhouse gases, especially carbon dioxide, are global warming, environmental pollution, and climate changed. The manufacturing industry in Indonesia contributes 28% of carbon emissions. An initiative to reduce carbon emissions is the collection end-of-life products to be reused. Remanufacturing aims to restore products value to its original state or even surpass it, offering the same high quality and warranty as new products. The motivations for remanufacturing included lowering costs, shortening manufacturing times, and reducing resources to improve profitability. Remanufacturing management is intricate due to its multistages, including collection of used products, disassembly of components, thorough cleaning, repair, and reassembly. This study determined the remanufacturing practices of PT. SKF Indonesia. This research investigates the reason, purpose, process, and difficulties faced by PT. SKF Indonesia in conducting remanufacturing. The study highlighted how the company collected the end-of-life product, how to conduct the remanufacturing process, the demand and marketing strategy of remanufacturing products.

Keywords

Remanufacturing, Product recovery, Bearing, SKF

Introduction

The primary consequences of greenhouse gases, especially carbon dioxide, are global warming, environmental pollution, and climate changed [1–5]. A growing number of nations are implementing and enforcing carbon emission policies via sustainable supply chain and circular economy strategies [6][7][8]. The manufacturing sector contributes significantly to releasing carbon emissions. In the US, manufacturing accounts for 23% of the country carbon emissions, whereas in Indonesia, the industrial sector is responsible for 28% of the nation carbon emissions [9][10]. In Indonesia, carbon emissions have increased by 7.5% in the last decade. Recovering the value of used-product has become a solution and priority for manufacturing firms to reduce carbon emissions.

Published:
May 31, 2024

Selection and Peer-review under the responsibility of the 6th BIS-STE 2024 Committee

There are several options for product recovery, as mentioned in Table 1 and shown in Figure 1. Reuse, means used-products are reused without modification. Repairing or fixing with simple repairs without any guarantees for the product. The quality of repairing products is less than new products. Reconditioning, used-products adjustments are made to product components to bring them back to work but not like new. Refurbishing involves significant cosmetic improvements that can restore a product to its original condition, albeit with reduced functionality. Remanufacturing involves performing a sequence of manufacturing operations that have reached the end of their lifespan to restore them to a condition that is identical to or surpasses their original state. Remanufacturing products offer the same quality and warranty as the new products. Recycle; the used product is converted into raw materials through the recycling process [11-14].

Table 1. Type of product recovery [11–13]

Product Recovery	Level of Disassembly	Raw Material	Quality Requirement	Product	Guarantee
Reuse	Product level	Used product/ component	Restore product to working order	Reuse without modification	No Guarantee
Repair	Product level	Used product/ component	Get the product to up and running again	Components were either repaired or exchanged	Guarantee only for repaired component
Refurbishing	Module level	Used product/ component	Verify and upgrade components to the designated standards	Certain modules have been repaired or replaced, with the possibility upgrading	Shorter guarantee period
Remanufacturing	Part level	Used product/ component	Examination all components and upgrade them to as new quality	Modules of old and new products are integrated into a new product, offering possibility upgrading	Same guarantee as new product
Cannibalization	Selective parts retrieval	Used product	Reuse of parts depends on necessity	Certain part recycled and reused	No Guarantee
Recycling	Material level	Used product/ component	Higher priority for original components; lower priority to other parts	Parts are recycled into new form of product	No Guarantee

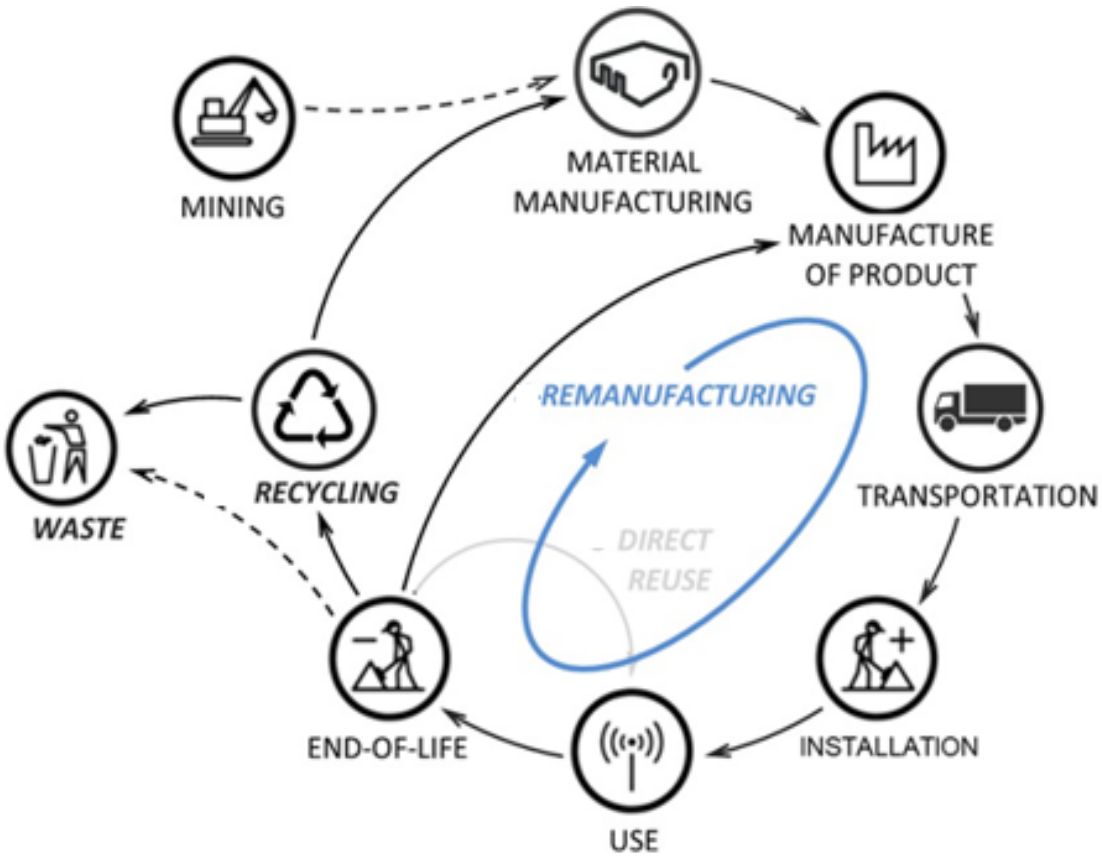

Figure 1. Product recovery option [15–17]

Remanufacturing is defined as the recovery value of end-used products to be manufactured into "like new" products with the same original or better function. Figure 2 visually show the different of remanufactured bearing, before and after remanufacturing process. Remanufactured products are manufactured in like-new conditions with the same quality and warranty as new products [11][18][19]. Remanufacturing is taking place in industries including aerospace, automotive, heavy-duty and off-road equipment, electronic and electrical equipment, machinery, medical equipment, furniture, rail and marine sectors, as cited in references [20–22]. Remanufacturing is carried out by HP, Caterpillar, Komatsu, Dell, Xerox, SKF [23-26].

The company's motivation to undertake remanufacturing is divided into three; economic, environmental, and social. Economic motivations include reducing raw material cost, reducing production cost, reducing equipment and machinery cost, and shortening manufacturing time. Environmental motivations include reducing raw material consumption, water, energy, reducing pollution and waste. Social motivation includes increased expertise, technology, and affordable product prices, as shown in Table 2.

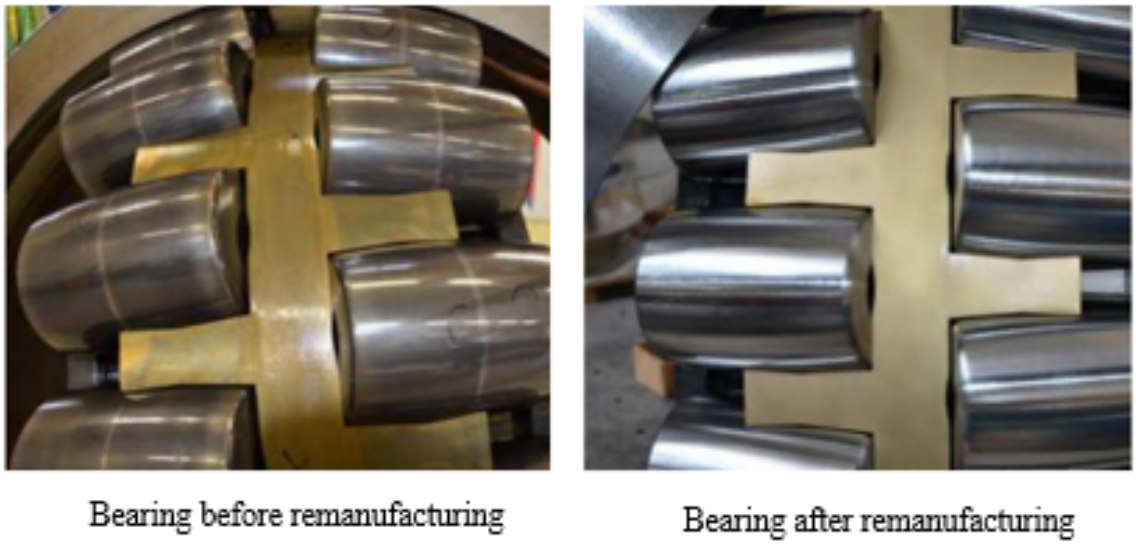

Figure 2. Before and after remanufacturing (based on information from SKF)

Table 2. Advantages of remanufacturing [18][21][27]

Motivation	Remanufacturing Advantages
Economy	Reduce production costs by minimizing the use of new materials
	Increase profits because production costs fall
	Increase customer satisfaction by providing quality products at competitive prices
	Extend product life
	Shorten build time
Environment	Reducing raw materials consumption
	Reducing energy and water usage
	Reducing carbon gas emissions
	Reduce pollution
	Reducing waste and piles of garbage
Social	Improve skills with training and new technology
	Increase customer satisfaction by providing trade-in services
	Offer competitive prices
	Provide jobs

The US remanufacturing industry is estimated to be worth billions of dollars annually and encompasses various products and industries, such as automotive components, heavy equipment, aerospace, and electronics. Japan also has a well-established remanufacturing industry, particularly in electronics and automotive components. Japan's remanufacturing industry is known for its high-quality products and strict standards, with many of the leading manufacturers in the country offering remanufactured products alongside their new products [18]. Overall, although both countries have strong remanufacturing industries, the US remanufacturing industry is considered larger in scale and size. China also has a growing remanufacturing industry, but it is still smaller compare to the US and Japan. The remanufacturing industry in China mainly involves automotive components, electronic products, and home appliances [28][29]. The remanufacturing industry is still relatively small in Indonesia but is growing as companies seek to reduce costs and waste by reusing materials and components.

Additionally, the Indonesian government has implemented policies to promote the growth of the remanufacturing industry as a way to create jobs and reduce environmental impact [30].

The European Union mandates a specific percentage of automobiles be recycled under the European Union End-of-Life Vehicle Directive. In Europe, regulations mandate that manufacturers of electronic goods be accountable for retrieving and responsibly disposing of their products, as outlined in the Waste Electrical and Electronic Equipment Directive [6]. Japan's Home Appliance Recycling Law governs the collection of used items, including appliances such as air conditioners, televisions, refrigerators, freezers, and washing machines. Japan also requires manufacturers to collect and recycle automotive components through the End-of-Life Vehicle Recycling Law. Car owners in Japan are also required to pay recycling fees when purchasing a vehicle [18][22]. The United States already has a remanufacturing industry standard; RIC001.1-2016 Specifications for the Process of Remanufacturing. The standard establishes benchmarks for remanufacturing processes and outlines specific criteria that define remanufacturing processes and distinguish them from other manufacturing techniques. These standard specifications guarantee that the products supplied to customers by the remanufacturing companies are dependable and of superior quality. Meanwhile, Indonesia currently does not have regulations regarding remanufacturing. Existing laws focus more on regulations on the import of reconditioned goods. Due to the lack of regulation, the remanufacturing industry in Indonesia is relatively small compared to other countries [30].

This paper presents the remanufacturing practices in PT. SKF Indonesia. It investigates the reasons, purpose, process and difficulties faced by PT. SKF Indonesia. During interviews and discussions, the company explained their motives to do remanufacturing, how they did it and their obstacles. We highlighted how they collect the end-of-life product, how to remanufacture, the demand, price and marketing strategy of remanufacturing products. This research provides scientific contributions in remanufacturing practices as a reference for decision makers to perform out analysis to be able to choose a product recovery strategy, especially remanufacturing. The majority of bearing remanufacturing research focuses on process and quality [31], not many to analyze from an economic, social and environmental perspective. Research in the area of closed-loop supply chains and carbon mitigation policies is growing, but surprisingly, few studies have focused on remanufacturing. Therefore, future research in this field is strongly encouraged.

Method

This research involves case study of PT. SKF Indonesia. During interviews and discussions, the company explained their motives to do remanufacturing, how they did it and their obstacles. We highlighted how the firm collected the end-of-life product, how to conduct the remanufacturing process, demand and marketing strategy of

remanufacturing product.The information was gathered from both primary and secondary sources. Primary data were obtained directly from experts and company sources through interviews, observations, and questionnaires. Secondary data are additional or complementary data obtained from literature and information from the internet in the form of historical notes or reports, including company website and company annual reports. The experts interviewed in this research are Marketing and Administration Director, Manufacturing Director, Procurement and Material Flow Manager, Maintenance Manager and Remanufacturing Engineer. The questions are divided into two sections as describe in Table 3, first section presents general information of remanufacturing company and second section presents remanufacturing product characteristic.

Table 3. Questions during interview and discussions

No	**Section 1–General information of respondents and firm**
1	Full name
2	Email
3	Position/title
4	Division of work in the company
5	Age
6	Last education
7	Years of Service
8	Length of experience in the position
9	Total number of Employees
No	**Section 2–Remanufacturing products and characteristic**
10	How many SKUs of remanufactured products?
11	What is the main motivation of the company in carrying out remanufacturing production?
12	What is the marketing strategy for remanufactured products?
13	Do customers prefer new products over remanufactured products?
14	How to recover raw materials (used-products from customers)?
15	Is there any cooperation to obtain these used-products?
16	What is the production ratio between new and remanufactured products?
17	Is there a quality differences between a new and a remanufactured product?
18	Is there a warranty differences between a new and a remanufactured product?
19	Is there a service center difference between new and remanufactured products?
20	Is there any price difference between a new and a remanufactured product?
21	What is the production efficiency between new and remanufactured products?
22	Is the demand for new products higher than remanufactured products?
23	Are sales of new products higher than remanufactured products?
24	What are the main challanging in the remanufacturing industry?
25	Are there regulations in Indonesia concerning remanufacturing?
26	Does the regulation help?
27	What is the production efficiency between new and remanufactured products?
28	What are the stages of the process in remanufacturing?
29	From the above stages, which is the most difficult remanufacturing process?
30	Are there a remanufacturing process done by a third party (outsourcing)?

Results and Discussion

SKF (Svenska Kullagerfabriken AB) is a multinational company that produces various engine and lubricant systems. The company was founded in 1907 with its headquarters in Gothenburg, Sweden. SKF has 115 years of experience, operates in 140 countries and has 17,000 distributors. The company has 20 remanufacturing facilities and has 25 years of remanufacturing experiences. It is estimated that approximately 583 MT of carbon emissions could be avoided in 2021 at each remanufacturing facility. The Indonesian factory opened a remanufacturing facility located in Cakung, East Jakarta in July 2022. The total area of the company in Indonesia is 53,000 m2.

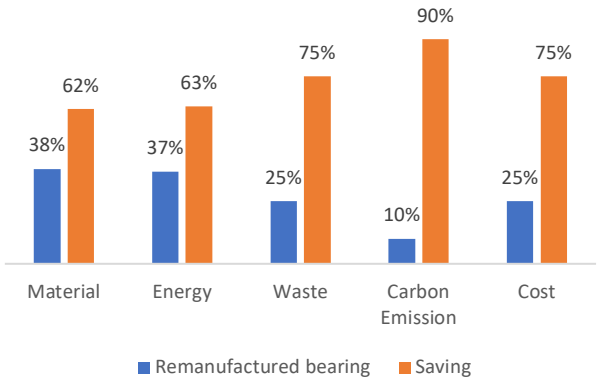

Figure 3. Requirement and amount of saving for remanufactured bearings

The main motivation for company to establish remanufacturing division as commitment to sustainability. The goal of remanufacturing products is to extend the service life of bearings at a lower cost and in a shorter time compared to new bearing. Bearing service life is often shorter than expected because of fatigue, corrosion, wear, electrical erosion, plastic deformation, fracture, or cracking. To extend the service life of bearings, the company remanufactures them before irreparable damage occurs. In addition, remanufacturing is also good for the environment because it requires less energy than new production. This purpose aligned and similar to previous studies [11][18][30].

Bearing remanufactured products require only 38% of the material and 37% of the energy compared to making new bearings. Remanufacturing can reduce carbon emissions by up to 90%. Apart from that, it can save materials by up to 70% and produce less waste, only 25%. The needs and savings of the remanufacturing process in terms of materials, waste, and costs are outlined in Figure 3. Another advantage of remanufacturing reduces costs and improve waiting times. The average cost of making a remanufactured bearing is 25% compared to making a new bearing. Furthermore, remanufacturing can reduce price and improve lead times [5][18][19].

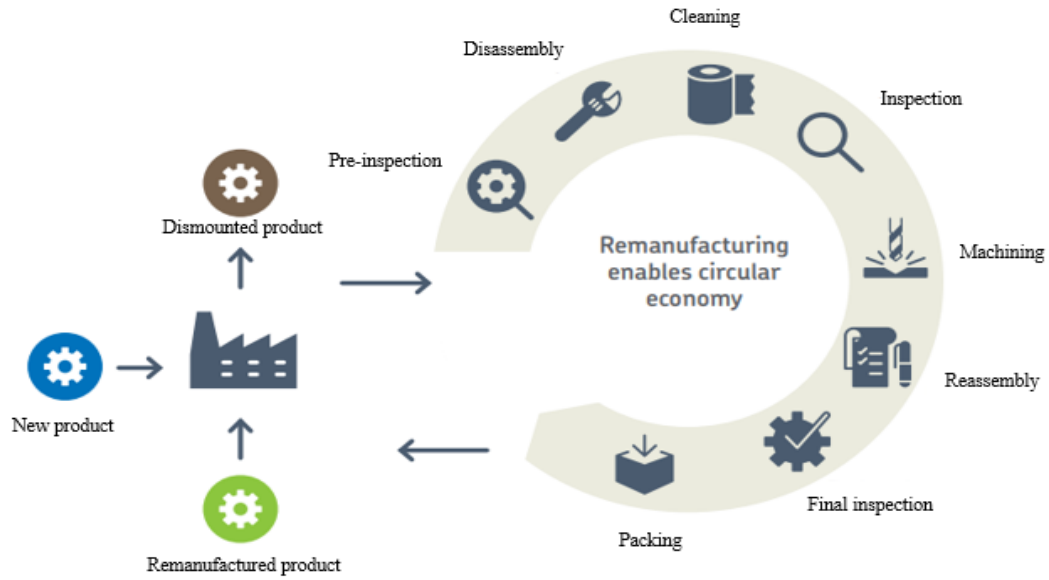

Figure 4. Remanufacturing process of bearing (based on information from SKF)

Remanufacturing process in SKF consists of two main parts; analysis and remanufacturing process. The analysis process includes cleaning, inspection, documentation, and remanufacturing recommendations. The remanufacturing process consists of remanufacturing all components, machining, quality inspection, assembly, final inspection, packing, and shipping. These two processes are depicted in Figure 4 and Table 4. All process is performed in a remanufacturing facility, and no process is sourced to other party according to respondents.

Table 4. Stages of remanufacturing process (based on information from SKF)

Remanufacturing Stages	Description
Collected used-product	Used-product are collected from customer and coming to warehouse
Pre-inspection	Inspected to assess their status which either be remanufacturing possible, potential and not possible
Disassembly	Components are disassembled to take the core and part that can be used
Cleaning	Components cleaned
Inspection	Components checked
Machining	Regrinding inner rings and outer rings
Reassembly	All components are assembled
Final inspection	Products are tested for function and performance
Packaging	Products are packaged

The company uses the same standards, processes, equipment, and quality assurance as new bearings to produce remanufactured products. SKF used ISO 15243:2017 as the reference for remanufacturing process. We can see in the Figure 5, example of abrasion wear. Green col represents remanufacturing possible, yellow col potential and red col not possible to be remanufactured. In addition, the company also provides remanufacturing services by changing to higher specifications and adding more equipment if needed. For traceability, the company uniquely mark remanufactured products to enable traceability.

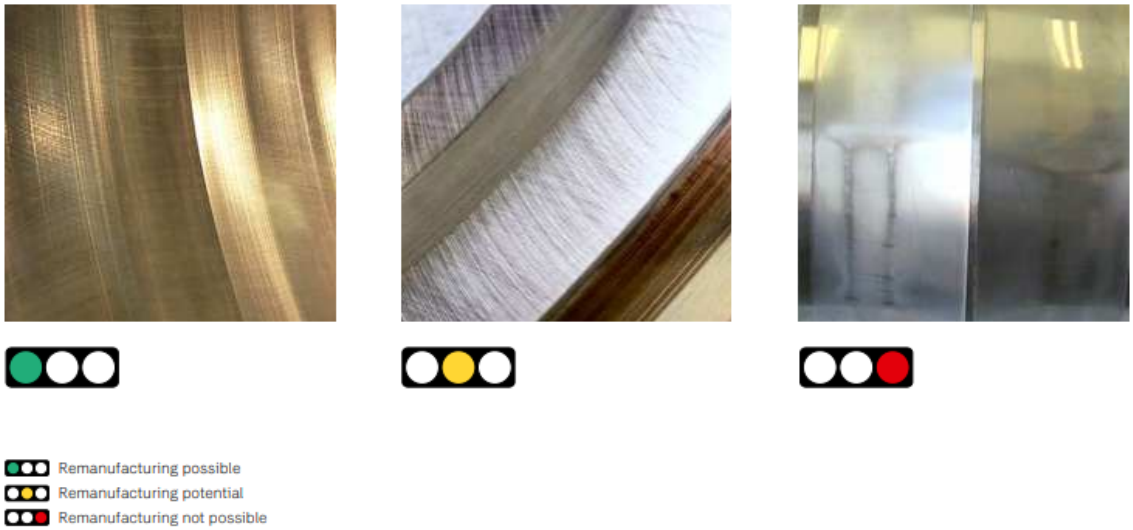

Figure 5. Remanufacturing process of bearing (based on information from SKF)

Not all bearings can be remanufactured. Bearing remanufacturing is suitable for large bearings, spherical roller bearings, backing bearings, and slewing bearings, as shown in Figure 6. Remanufactured bearing suit for many industries, such as metal, pulp and paper, energy, mining, marine, cement, food and beverage also railway. Bearings with diameters greater than 300 mm are economically valuable for remanufacturing. Most of large bearings is not produce in Indonesia. Remanufacturing in SKF Indonesia able to shorten lead time. To attract customers, the firm offers a trial purchase of remanufacturing product to existing customers in order to save costs and time. To collect used-product, SKF cooperates with customers to send used bearing to remanufacturing facility. According to respondent, remanufacturing process is less efficient compare to new bearing since they process various sizes, so the settling time is different.

Figure 6. Suitable bearings for remanufacturing processes

Example of a remanufacturing case study at SKF:

a. Maintenance contract with steel manufacturing company in Eastern Europe. This partnership could save US$ 500,000 in 2007. Remanufacturing 600 kg of bearings can reduce CO2 emissions by 1 ton.
b. European steel companies replace approximately 2,000 bearings a year. However, because half of the replacements are remanufactured, the company reuses 10 tons of steel, preventing the use of 62,000 kWh of energy and eliminating almost 30 tons of CO2 emissions every year. This economic and ecological benefits, steel company improve delivery times, significantly from 6 months to 6 weeks.
c. A steel forging company in Italy used 3 remanufactured main bearings, saving almost 4000 kg of steel. Apart from that, it also saves around 20,000 kWh of energy and prevents more than 10,000 kg of carbon emissions.
d. Cement factories in Türkiye use remanufactured bearings at half the price of new bearings. In addition, the time saved was only 8 weeks from the 6 months needed to get a new bearing. Through the remanufacturing decision the cement factory saved time and costs and prevented 34 tons of carbon emissions from entering the atmosphere.

This research found that SKF has 25 years of remanufacturing experiences. The Indonesian factory opened its remanufacturing facility in July 2022. Their goal is to extend the service life of bearings at a lower cost and in a shorter time. Remanufactured bearings reduce cost, waste, material usage, carbon emissions and improve the lead time. The average price of a remanufactured bearings is 50-30% lower compared to making a new bearing. Remanufacturing stages are collected used-product, pre-inspection, disassembly, cleaning, inspection, machining, reassembly, final inspection and packaging. SKF used ISO 15243:2017 as the reference for remanufacturing process which uses same processes, equipment, and quality assurance as new bearings. The company also provides remanufacturing services by changing to higher specifications and adding more equipment if needed. Bearings with diameters greater than 300 mm are economically valuable for remanufacturing. Most of these large bearings is not produce in Indonesia so that remanufacturing practices in Indonesia able to shorten lead time. SKF is facing some difficulty to convince their customer about the quality of remanufacturing product. Furthermore, with same quality and guarantee, SKF has proven that remanufacturing products is a good practice not only for the environment, but also in terms of economic and social. This result is aligned and similar to previous studies [11][18][30]. Even though remanufacturing practices is not widely common in Indonesia, but it has big potential in the future [30].

Conclusion

Remanufacturing involves performing a sequence of manufacturing operations that have reached the end of their lifespan to restore them to a condition that is identical to or surpasses their original state. The motivations for remanufacturing are lowering costs, shorter manufacturing times, and reducing resources to achieve better profitability. PT. SKF Indonesia open its remanufacturing facility on July 2022. The main motivation of company to establish remanufacturing division as commitment to sustainability. Further the goal is to extend the service life of bearings at a lower cost, competitive price and in a shorter time compared to new ones. SKF use uniquely mark remanufactured for traceability. Beside its advantages, PT. SKF Indonesia face difficulty to convince customers about the quality remanufacturing product. By providing the same quality, process and warranty, SKF was able to convince their customers to grow their remanufacturing line. This study shows that remanufacturing bearing is a good practice not only for the environment, but also in the economic and social terms.

The remanufacturing industry is still relatively small in Indonesia, but is growing as companies seek to reduce costs and waste by reusing materials and components. The majority of bearing remanufacturing research focuses on process and quality, not many to analyze from an economic, social and environmental perspective. Research about closed-loop supply chains and carbon mitigation policies is growing, but few studies have focused on remanufacturing. Future research in this field is therefore strongly encouraged. Furthermore, the study of remanufacturing in Indonesia has mostly focused on heavy-duty equipment. Thus, we recomended future studies in other type of industries, such us automotive, electronics and electrical equipment and furniture.

Acknowledgement

The authors received no financial support for the research, authorship, and publication of this article. The authors thank the staffs and management of PT. SKF Indonesia who provided valuable support, data, and input for this reseach.

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